UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

AVIDYNE CORPORATION, a Delaware corporation, Plaintiff, v. L-3 COMMUNICATIONS AVIONICS SYSTEMS, INC., f/k/a B.F. GOODRICH AVIONICS SYSTEMS, INC., a Delaware corporation, Defendant.	Civil Action No. 05-11098 GAO

PLAINTIFF'S OPENING *MARKMAN* BRIEF

TABLE OF CONTENTS

Page

TABLE OF AUTHORITIES

Cases **Pages**

Statutes and Rules

Dictionary

Interpretation of patent claims is exclusively within the court's province. *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 372 (1996). Plaintiff Avidyne Corporation ("Avidyne") submits this brief in support of its interpretation of certain terms used in U. S. Patent 5,841,018 (issued Nov. 24, 1998)("'018 Patent" and attached at Exhibit 1).

I. INTRODUCTION

Avidyne and L-3 are the parties to this action. Avidyne is a Delaware corporation with its principal place of business in Lincoln, Massachusetts. Avidyne designs, manufactures, and sells integrated flight deck systems for aircraft. Defendants L-3 Communications Avionics Systems, Inc., f/k/a B.F. Goodrich Avionics Systems, Inc., ("L-3") is the assignee of the '018 Patent which it has accused Avidyne of infringing. L-3 is also a Delaware corporation with its principal place of business in Grand Rapids, Michigan. Avidyne instituted this action on May 25, 2005 seeking a declaration that it does not infringe the '018 Patent and that the patent is invalid. L-3 counterclaimed alleging infringement.

The '018 Patent claims a simple method of compensating for orientation errors that arise from the imprecise installation of an Attitude Determining Device ("ADD") on board a mobile craft, such as an airplane. This patent does not disclose or claim the complicated and valuable technology of an ADD. Rather, it is limited to a method of calibrating, or correcting, the inaccurate attitude measured by an ADD by effectively subtracting the installation offset angle from the measured angle. To quote the specification, the claimed method corrects a pre-compensated "attitude measurement of … [an Attitude Determining Device] for an unknown installation orientation with respect to the reference coordinate system of the craft." ('018 Patent 1:12-14).

The ‘018 Patent was filed on December 13, 1996, issued on November 24, 1998, and includes 20 claims. Claims 1 and 16 are the only independent claims upon which all other claims depend directly or indirectly. By order of this court dated September 11, 2006, claims 1 and 16 are the only claims to be considered for construction at this time.

The parties were able to agree on the construction of several terms contained in claims 1 and 16, and the parties filed a stipulation to memorialize those constructions. Because the parties were not able to reach agreement on all the claim terms, Avidyne seeks construction of the following disputed terms and phrases (highlighted in bold text):

1. A method of compensating for installation orientation of an attitude determining device on-board a mobile craft with respect to a reference coordinate system of said craft to obtain attitude information of said craft from said device based on an earth frame coordinate system, said method comprising the steps of:

> installing said **attitude determining device** on-board said mobile craft at an unknown orientation with respect to said reference coordinate system of said craft;
>
> **sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device**;
>
> **measuring an attitude of said mobile craft with said attitude determining device**; and
>
> **compensating said craft attitude measurement of said device with said static orientation measurement to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system**.

16. A method of compensating for installation orientation of an attitude determining device on-board a mobile craft with respect to a reference coordinate system of said craft to obtain attitude information of said craft from said device based on an earth frame coordinate system, said method comprising the steps of:[1]

> installing said **attitude determining device** on-board said mobile craft at an unknown orientation with respect to said reference coordinate system of said craft;

[1] The Court should note that claims 1 and 16 are nearly identical in all material respects except that claim 16 contains the additional steps of storing and retrieving certain measurements.

sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device;

storing said static orientation measurement in a memory;

measuring an attitude of said mobile craft with said attitude determining device;

retrieving said static orientation measurement from said memory to a processor of said device; and

compensating said craft attitude measurement with said retrieved static orientation measurement in said processor to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.

II. CLAIM INTERPRETATION

Two steps are required to determine whether a patent has been infringed. First, the court construes the scope and meaning of the claim language. Second, the fact finder compares the claim as construed to the accused product or process. *Cybor Corp. v. Fas Techs., Inc.,* 138 F.3d 1448, 1454 (Fed. Cir. 1998).

In *Phillips v. AWH Corp.* 415 F.3d 1303 (Fed. Cir. 2005) the Federal Circuit clarified how to properly construe claims. The Court ruled that while claim construction is not a rigid sequential process, certain evidence is entitled to more weight to ensure proper interpretation of the claims. *Id.* at 1324. Section 112 of the Patent Act (35 U.S.C. § 112) (2006) requires a patentee to "distinctly [claim] the subject matter which the applicant regards as his invention" and to include a "written description of the invention … in full, clear, concise, and exact terms" in the specification. This, as the court in *Phillips* stated, "frame[s] the issue of claim interpretation for us." *Id.* at 1312.

The claims "define the invention" and the words of a claim are "given their ordinary and customary meaning." *Vitronics Corp. v. Conceptronic, Inc.,* 90 F.3d 1576, 1582, 1584 (Fed. Cir. 1996). The "ordinary and customary meaning of a claim term is the meaning that the term would

have to a person of ordinary skill in the art in question at the time of the invention." *Phillips,* 415 F.3d at 1313; *see also Innova/Pure Water, Inc. v. Safari Water Filtration Sys., Inc.,* 381 F.3d 1111, 1116 (Fed. Cir. 2004). Some claim language will be very clear and a general purpose dictionary may be all that is required to ascertain the correct meaning of a word or phrase. Indeed, the Federal Circuit has expressly endorsed the use of dictionaries, observing that "judges are free to consult dictionaries and technical treaties at any time in order to better understand the underlying technology." *Vitronics,* 90 F.3d at 1584 n.6. But a dictionary meaning can never trump a definition found in the patent. *Id.*

Often, the claim language is more technical and "requires examination of terms that have a particular meaning in a field of art." *Phillips,* 415 F.3d at 1314. To construe such language, the court examines "those sources available to the public that show what a person of skill in the art would have understood disputed claim language to mean." *Innova,* 381 F.3d at 1116. Examples of such sources include "the words of the claims themselves, the remainder of the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art." *Id.*; *see also Vitronics,* 90 F.3d at 1582-83. Because intrinsic evidence, such as the specification, "describe[s] the invention set forth in the claims" the court must give greater weight to such evidence than to extrinsic evidence. *Phillips,* 415 F.3d at 1312. The *Phillips* Court explained that intrinsic evidence refers to the entire patent instrument, which encompasses:

(i) the specification "the single best guide to the meaning of a disputed term" and includes the written description and the actual claims; (*Id.* at 1315)

(ii) the prosecution history, if in evidence, which documents how the inventor understood and explained the patent to the PTO (*Id.* at 1317); and

(iii) prior art cited by the inventor, which is included in the prosecution history and the specification. *Id.; Autogiro Co. of Am. v. United States* 384 F.2d 391, 399 (Ct. Cl. 1967).

The Federal Circuit has also authorized the use of extrinsic evidence if such evidence would assist in the construction of the claim language. Extrinsic evidence such as expert testimony, dictionaries, and treatises may help explain the relevant art and, therefore the meaning of technical claim language. However, such evidence should be given less weight compared to the patent and prosecution history "in determining 'the legally operative meaning of claim language.'" *Phillips,* 415 F.3d at 1317 (citing *C.R. Bard, Inc., v. U.S. Surgical Corp.,* 388 F.3d 858, 862 (Fed. Cir. 2004)).

An additional consideration when interpreting method patents is whether the elements must be performed sequentially to practice the patent. Such a construction is appropriate when "the ordering of the steps of a process patent in combination with language in subsequent steps referring back to structure formed in previous steps strongly suggests that the steps must proceed in chronological order." *Thorn EMI N. Am., Inc., v. Intel Corp.* 928 F. Supp. 449, 457 (D. Del. 1996)(citing *Loral Fairchild Corp. v. Victor Co. of Japan, Ltd.,* 906 F. Supp. 798, 805 (E.D.N.Y. 1995)), *see also Mantech Envtl. Corp. v. Hudson Envtl. Servs., Inc.,* 152 F.3d 1368, 1376 (Fed. Cir. 1998) (upholding the lower court's construction that process steps as claimed in the patent must be performed sequentially). The specification is appropriate evidence of such an interpretation. As the court in *Loral Fairchild Corp.* held, while the specification does not limit the scope of the claims (absent functional claiming language) the specification is the primary tool the court uses to inform itself of the claim's meaning. *Id.* at 805.

III. THE '018 PATENT

As indicated above, the '018 Patent is directed to "a method of compensating for installation orientation of an attitude determining device onboard a craft." ('018 Patent, 1:1-5).

As its name suggests, the ADD is a navigation instrument that determines its own attitude, or angular orientation, relative to a reference frame. The '018 Patent describes the ADD as a device that determines a craft's attitude in relation to a coordinate system that is fixed relative to the earth. ('018 Patent 1:15-18). This system may be an orthogonal (three axis) system represented by the conventional axis nomenclature (X, Y, and Z axes). The earth reference coordinate system is referred to as "earth frame" in the '018 Patent. ('018 Patent at 1:17-18).

An ADD has two primary components: sensor(s) and a processor. The sensors may be, for example, an acceleration sensor and a rate sensor. These sensors are used to detect acceleration and motion of the craft. ('018 Patent 3:18-31). The output of the sensors is processed by the processor to determine attitude. ('018 Patent 3:34-40). The '018 Patent discloses a method of compensating the calculated attitude for installation orientation errors when the ADD is installed at an unknown orientation with respect to the craft's coordinate system. As illustrated in Figure 3 of the '018 Patent, installation inaccuracy arises when an ADD (20) is installed in the craft instrument panel (30) in an orientation that does not track the X, Y, or Z axes of the aircraft coordinate system. Rather, it may be installed at an unknown orientation (40) with respect to the craft's coordinate system.

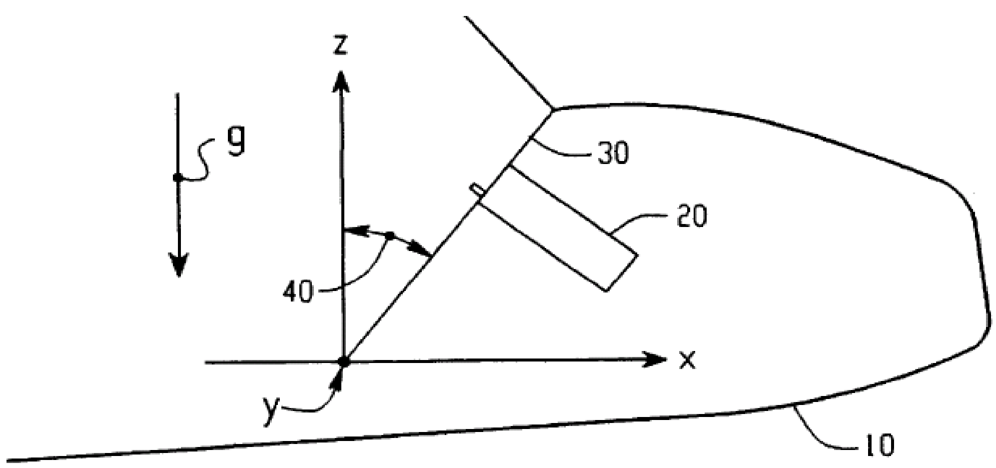


Fig. 3

10144155.1

IV. THE STEPS IN THE METHODOLOGY OF THE '018 PATENT

Because the inventors of the '018 Patent did not invent an ADD (which does virtually all of the work in the allegedly novel method), the invention is exceedingly simple. Specifically, the '018 Patent requires the following steps:

1. The ADD is installed on the craft at an unknown orientation and the aircraft is either actually or constructively leveled. ('018 Patent 3:12-18; 5:22-44).

2. When the craft is at rest and level the ADD is powered up. ('018 Patent 4:39). The ADD's internal processor, deriving data from the ADD's sensors, calculates the installation orientation of the ADD relative to earth frame. This measurement is referred to as the "static orientation" in the '018 Patent. ('018 Patent 4:43-58; 5:39-44; 6:1-4). The calculated static orientation is stored in the memory of the ADD ('018 Patent 5:39-44) so that it can later be retrieved. ('018 Patent 5:1-21).

3. The processor, deriving data from the ADD's sensors, calculates a pre-compensated attitude of the ADD relative to the earth frame. ('018 Patent 4:50-54).

4. The processor then compensates this pre-compensated attitude reading by mathematically applying the previously determined static orientation to the pre-compensated attitude measurement, thereby giving an accurate attitude reading. ('018 Patent 4:50-67).

V. DISCUSSION OF DISPUTED TERMS

As reflected in the stipulation filed by the parties on September 28, 2006 the parties were able to reach agreement on the following terms:

Claim Language	Agreed Upon Construction
Attitude	the angular position of a craft relative

Claim Language	Agreed Upon Construction
	to a frame of reference, such as but not limited to the amount of tilting about the wings and body of an aircraft relative to the earth.
Reference Coordinate System	a system of coordinates, or values, using a reference point, or starting point, for navigation.
Earth Frame Coordinate System	a theoretical frame of reference defined by the earth's surface and a vertical axis that is in the direction of gravity (perpendicular to the earth's surface).
Installing said Attitude Determining Device on-board said mobile craft	securing, mounting, or affixing the attitude determining device to the mobile craft.
Unknown orientation with respect to said reference coordinate system of said craft	unknown angular position of the installed attitude determining device relative to the reference frame of the craft
Mobile Craft	a space, air, land, or water vessel or vehicle, manned or unmanned, capable of moving

(See Exhibit 2). Avidyne seeks construction of the terms identified below.

A. Attitude Determining Device

The parties have agreed that "attitude" is an angular position, and thus an Attitude Determining Device is a device that determines angular position. As shown in the embodiments of the ADD disclosed in the '018 Patent, the ADD must possess two main components: sensors and a processor. The sensors determine acceleration and motion. ('018 Patent 3:12-31). The processor receives the output from the sensors and calculates the attitude (angular position) of the device based on the sensor data. ('018 Patent 3:19-40; 4:1-6).

FIG 5 is a "block diagram schematic representing a suitable embodiment of an attitude determining device for performing the method in accordance with the present invention." ('018 Patent 2:48-52).

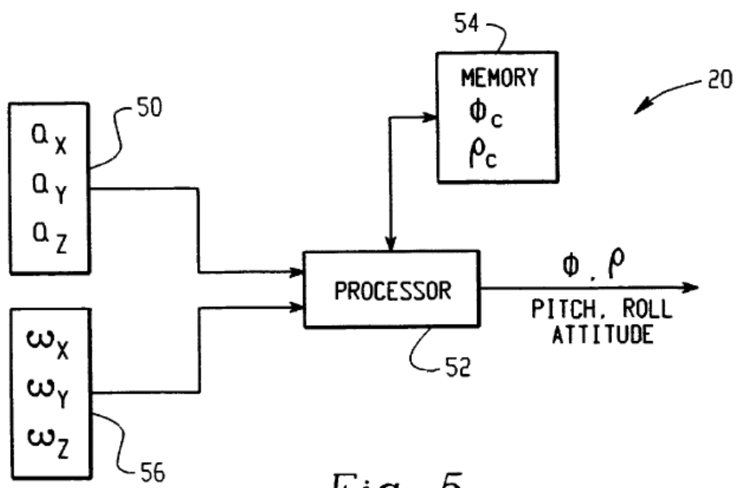


Fig. 5

The processor is represented by 52, the rate sensors are represented by 56, and the acceleration sensors are represented by 50. The alternative embodiment illustrated in FIG 6 also requires the ADD to have a processor (52) and sensors (56 and 58).

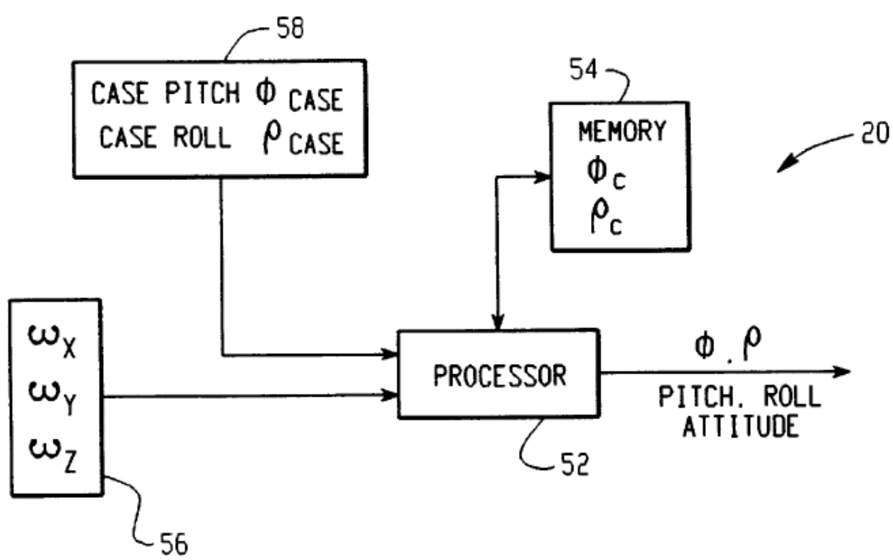


Fig. 6

Therefore, the correct construction of the term "Attitude Determining Device" as used in the '018 Patent is ***a device that includes sensors and a processor for processing the output of the sensors to determine attitude.***

B. <u>Sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device.</u>

"Sensing" is not explicitly defined in the patent. The ordinary and customary meaning of the term is "[t]o detect automatically." *Webster's New Riverside Dictionary* 618 (revised ed. 1996). This definition conforms to the explanation of this sensing step in the specification: "[U]pon installation of the device 20 on the instrumentation panel 30 of the craft 10, whose reference coordinate axes have been leveled to coincide with earth frame, the installation orientation thereof is automatically measured [or detected] by the installed device… ." ('018 Patent 4:7-11; *see also* '018 Patent 1:59-63). Importing this definition into the claim, the sensing step of claims 1 and 16 requires that the ADD automatically detect its own inertial orientation in relation to the earth frame coordinate system when the craft is not moving. This step is described in the specification at 4:35-58. The resulting calculation is the "static orientation measurement" of the ADD. Once determined, the static orientation measurement is later used in the final step of the claim method, the compensating step.

Installation orientation of the ADD is an angular position relative to earth frame. In FIG. 3, the ADD is installed at an unknown angle 40. Because the craft has been leveled, its installation orientation is relative to earth frame. ('018 Patent 4:7-11).

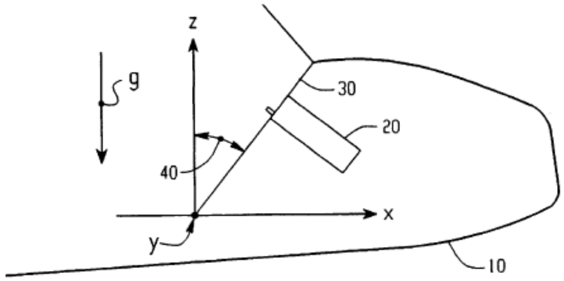


Fig. 3

In FIG. 4A and FIG. 4B the sensing step is depicted visually. This step is also described in the specification at 4:7-34. The diagrams clearly show the ADD installed on the panel as an angular relationship to the earth frame coordinate system.

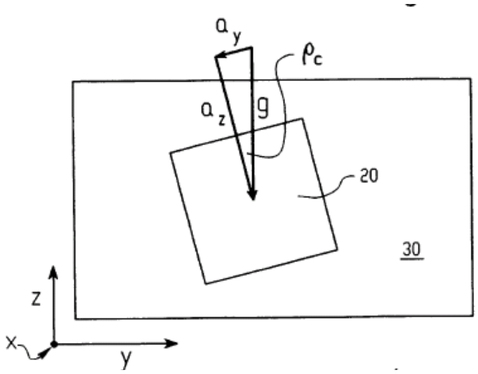
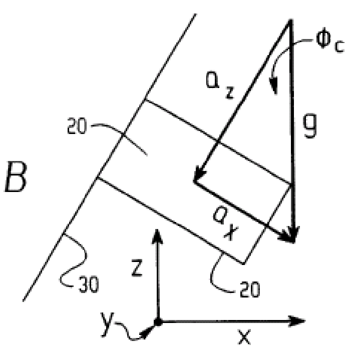


Fig. 4A

Fig. 4B



Read properly and in accordance with the specification, this claim should therefore be construed as *automatically determining the angular position of the installed attitude determining device relative to earth frame while the craft is not moving to obtain a static orientation measurement of the device.*

10144155.1

C. Measuring an attitude of said mobile craft with said attitude determining device

This element constitutes the third and fourth steps of claims 1 and 16 respectively ("measuring step"). The measuring step actually describes an ordinary function of any ADD, namely, that the device measure its own attitude. ('018 Patent 1:24-31; 3:35-40; *see also* Exhibit 3 *Expert Report of Dr. Marshall Kaplan* page 3). If an ADD were installed in alignment with the craft's axes, the ADD's attitude measurement (measurement of its own attitude) would be the same as the attitude of the craft. Hence there would be no need to compensate the attitude reading. Because the method disclosed in the '018 Patent assumes that the ADD is installed at an unknown orientation, it is necessary that a correction for the installation angle offset be undertaken.

The '018 Patent accommodates for an installation of an ADD that is *not* aligned with the craft's axes. As the patent explains, "[a]ny inaccuracy in installing an attitude determining device in the craft with respect to the reference coordinate system thereof will result in *inaccurate measurement* … of the attitude of the craft." ('018 Patent 1:32-35) (emphasis added). The method disclosed in the patent resolves this problem with a simple mathematical correction at the end of the installation process. ('018 Patent 1:32-49).

The measurement derived from this third "measuring step" is an inaccurate and an uncompensated attitude of the mobile craft. In short, it is a pre-compensated attitude measurement. Therefore, this measurement cannot be *the* attitude of the mobile craft. It can only be *an* attitude of the mobile craft. Indeed, if the attitude measured by the ADD in this measuring step accurately reflected the attitude of the craft, there would be no need to later compensate that measurement with the static orientation measurement. Whatever craft attitude measurement results, it must then be "compensated therewith in a processor of the device." ('018 Patent 1: 61-62). In light of the foregoing this measuring step must be construed to mean

processing the output of the sensors of the attitude determining device to determine a pre-compensated attitude of the mobile craft.

D. Compensating said craft attitude measurement of said device with said static orientation measurement to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.

Because this element specifically references "*said* static orientation measurement" of element 2 (sensing step) and the "*said* craft attitude measurement" of element 3 (measuring step) (emphasis added), the compensation or correction can only occur after the completion of both the sensing and measuring steps. Claims 1 and 16 do not permit any deviation from the specific sequence claimed therein.

The specification confirms that the sequence of steps (installation, sensing, measuring, and finally compensation) is a fundamental part of the invention. The Patent Abstract clearly outlines the methodology as having four sequential steps.[2] First, "[i]n accordance with the disclosed method, an attitude determining device … is installed onboard a mobile craft … at an unknown orientation with respect to the reference coordinate system of the craft… ." ('018 Patent, Abstract). Second, the attitude determining device "senses its installation orientation with respect to an earth frame coordinate system when the craft is at rest to obtain a static orientation measurement… ." *Id.* "*Thereafter*, an attitude of the mobile craft with respect to the earth frame is measured with the attitude determining device… ." *Id.* (emphasis added). Finally, in describing the compensating step the Abstract states "*[a]nd such measurement* is compensated with the static orientation measurement to obtain attitude information of the craft's reference coordinate system with respect to the earth frame coordinate system." *Id.* (emphasis added).

[2] As the Abstract is part of the specification it can be consulted along with the rest of the patent documents to give the claims their true meaning. *Pandrol USA, LP v. Airboss Ry. Prods.*, 320 F.3d 1354, 1363 (Fed. Cir. 2003); *800 Adept, Inc. v. Murex Secs., Ltd.,* 2006 U.S. Dist. LEXIS 53696 *35-36 (M.D. Fla. Aug. 3, 2006).

This precise sequence is recited almost verbatim at '018 Patent 1:66-2:9:

> In accordance with the present invention, an attitude determining device which is installed onboard a mobile craft at an unknown orientation with respect to the reference coordinate system of the craft senses its installation orientation with respect to an earth frame coordinate system when the craft is at rest to obtain a static orientation measurement. An attitude of the mobile craft is measured with the attitude determining device and such measurement is compensated with the static orientation measurement to obtain attitude information of the craft's reference coordinate system with respect to the earth frame coordinate system.

Similarly, the specification states that "[t]he static installation orientation is automatically determined by the device itself and the attitude measurement is compensated ***therewith*** in a processor of the device." ('018 Patent 1:59-62) (emphasis added). These passages from the abstract and specification make clear that the '018 Patent claims a method that follows a precise sequence: installation, sensing, measuring, and – finally – compensating.

Note also the language at '018 Patent at 5:15-20: "[i]n operation, the processor receives the installation orientation angles Φ_{case} and P_{case} measured by the level sensors [the sensing step]… and stores them in the non-volatile memory as Φ_c and P_c to be ***accessed subsequently*** in compensating for the ***attitude angle measurements***… ." (emphasis added). To be accessed "subsequently" as the specification describes, the sensing step of element 2 must occur prior to the compensating step. Also, attitude angle measurements must have been calculated prior to compensating because that step, as the entire patent describes, requires both the static orientation measurement ***and*** a measured craft attitude reading to effectuate the compensation, or correction as required by the last element of claim 1.

In light of the foregoing, the proper construction of this term is *applying said static orientation measurement (determined in said sensing step) to the pre-compensated attitude of the craft (determined in said measuring step) to mathematically correct the pre-compensated*

attitude of the craft (determined in said measuring step) by adjusting for the difference between that pre-compensated measured attitude of the craft and the craft's actual attitude relative to the earth frame.

E. Storing said static orientation measurement in memory

Element 3 of claim 16 recites that the static orientation measurement is stored in memory. As stated in the specification, "the installation orientation thereof is automatically measured by the installed device 20 [resulting in a static orientation measurement] and stored in a non-volatile memory thereof." ('018 Patent 4:10-12). The remaining language of claim 16 makes clear that the static orientation measurement must be retained in memory in the same form as the initial measurement. Element 5 requires the "[retrieval of] said static orientation measurement from said memory to a processor of said device." ('018 Patent 8:18-20). The use of the word "said" mandates that the measurement is stored in the same way as it was calculated. In addition, the specification supports the static orientation measurement be stored permanently in a non volatile memory. Referring again to FIG 5, the memory 54 shows the retention of Φ_c and P_c.

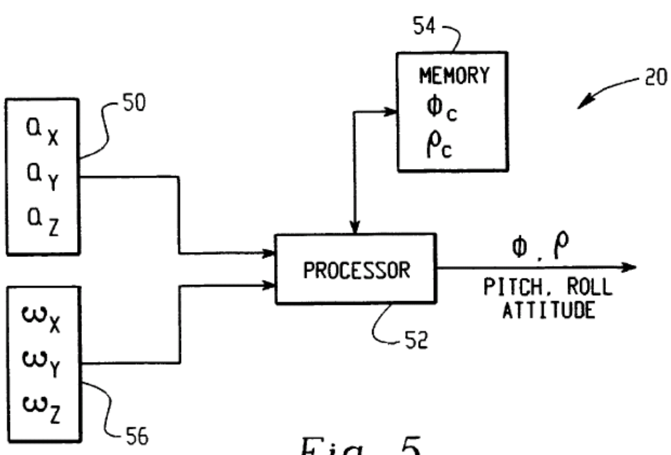


Fig. 5

The specification states that these installation angles "are determined by the processor 52 from the static acceleration measurements based on the trigonometric function described above and

are stored in a non-volatile memory 54… ." ('018 Patent 4:63-66). The specification then explains that power to the device can be removed. However, when the device is turned back on again, attitude of the aircraft can "be correctly determined by processor 52 using Φ_c and P_c [still stored in and retrieved] from … memory." ('018 Patent 5:4-6).

Even though the patent specification states that in some embodiments, the static orientation measurement may not be saved once the device is switched off, this does not negate the fact that while the device is on the data must be stored in a persistent form. In the devices identified in the specification at 5:45-54, the static orientation measurement does not survive turning the device on and off only because there is no non-volatile memory. However, the specification states that more than one attitude measurement may need to be compensated while the device is on. ('018 Patent 5:50-54). To do so, the static orientation measurement must be available as needed for any compensation adjustments. Clearly, the static orientation measurement must remain in a consistent form for use in the compensation calculation to ensure a reliable result. The interpretation of the language of element 3 of claim 16 must convey the permanency of the static orientation measurement. Any other construction would make the methodology inoperable. Accordingly, the correct construction of this phrase is ***persistently retaining the static orientation measurement in a memory.***

F. <u>Retrieving said static orientation measurement from said memory to a processor of said device.</u>

The common meaning of the word retrieving is "to bring or get back : regain". (***Webster's Dictionary, supra,*** at 585). The specification definition is consistent. The specification explains that during this step of the claimed methodology "[t]he installation angels Φ_c and P_c are ***read*** from non-volatile memory 54 of the device 20…". ('018 Patent 4:45-50) (emphasis added). The meaning of the operative word "read" in the present context means "[t]o

obtain (information) from a storage medium, such as a magnetic disk." (*Webster's Dictionary, supra,* at 569). This step of the claim essentially requires the processor to obtain information that is being stored in memory. That is, the processor does not store this information and needs to "go and get it" from another component of the ADD. This is depicted graphically in FIG. 5: The double headed arrow suggests that the static orientation measurement passes to and from the processor, presumably when the processor needs that information.

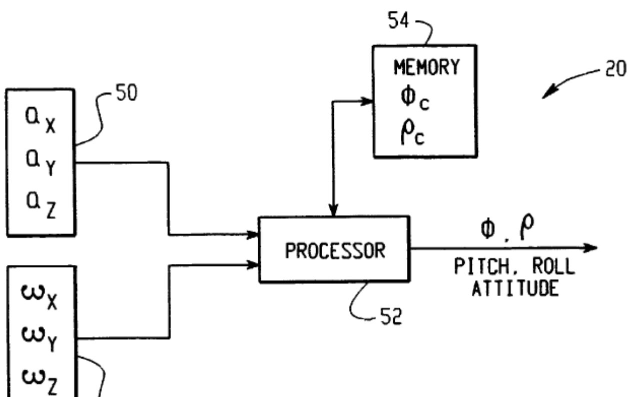


Fig. 5

The correct construction of this phrase is *obtaining the previously stored static orientation measurement and feeding it to the processor of the attitude determining device.*

G. <u>Compensating said craft attitude measurement with said retrieved static orientation measurement in said processor to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.</u>

This is the final element of claim 16. It is identical to element 4 of claim 1 except for the addition of the words "with said retrieved" (static orientation measurement) and "in said processor". The interpretation should therefore be the same as element 4 of claim 1 for the same reasons but with these differences reflected in the construction. The claim means *applying said retrieved static orientation measurement (determined in said sensing step) to the pre-compensated attitude of the craft (determined in said measuring step) in said processor to mathematically correct the pre-compensated attitude of the craft (determined in said measuring*

step) by adjusting for the difference between that pre-compensated measured attitude of the craft and the craft's actual attitude relative to earth.

VI. CONCLUSION

In light of the foregoing analysis, and based on the language of the '018 Patent and extrinsic evidence such as dictionary definitions, Avidyne asks that the Court construe the disputed claim language as follows:

Disputed Claim Language	**Proposed Construction of Dispute Terms**
Attitude Determining Device	A device that includes sensors and a processor for processing the output of the sensors to determine attitude.
Sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device.	Automatically determining the angular position of the installed attitude determining device relative to earth frame while the craft is not moving to obtain a static orientation measurement of the device.
Measuring an attitude of said mobile craft with said attitude determining device	Processing the output of the sensors of the attitude determining device to determine a pre-compensated attitude of the mobile craft.
Compensating said craft attitude measurement of said device with said static orientation measurement to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.	Applying said static orientation measurement (determined in said sensing step) to the pre-compensated attitude of the craft (determined in said measuring step) to mathematically correct the pre-compensated attitude of the craft (determined in said measuring step) by adjusting for the difference between that pre-compensated measured attitude of the craft and the craft's actual attitude relative to the earth frame.

Disputed Claim Language	**Proposed Construction of Dispute Terms**
Storing said static orientation measurement in memory	Persistently retaining the static orientation measurement in a memory.
Retrieving said static orientation measurement from said memory to a processor of said device.	Obtaining the previously stored static orientation measurement and feeding it to the processor of the attitude determining device.
Compensating said craft attitude measurement with said retrieved static orientation measurement in said processor to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.	Applying said retrieved static orientation measurement (determined in said sensing step) to the pre-compensated attitude of the craft (determined in said measuring step) in said processor to mathematically correct the pre-compensated attitude of the craft (determined in said measuring step) by adjusting for the difference between that pre-compensated measured attitude of the craft and the craft's actual attitude relative to earth.

AVIDYNE CORPORATION

Plaintiff

By Its Attorneys,

/s/ Maia H. Harris
Jason Kravitz (BBO# 565904)
Maia Harris (BBO# 648208)
NIXON PEABODY LLP
100 Summer Street
Boston, MA
(617) 345-1000

Frank W. Ryan *admitted pro hac vice*
Kate Cassidy *admitted pro hac vice*
NIXON PEABODY LLP
437 Madison Ave
New York, NY 10022
(212) 940 3000

Dated: October 2, 2006

CERTIFICATE OF SERVICE

I hereby certify that on this 2nd day of October, 2006, I caused a courtesy copy of the within document to be served via overnight mail on:

Terence J. Linn
Van Dyke, Gardner, Linn & Burkhart, LLP
Suite 207
2851 Charlevoix Drive S.E.
Grand Rapids, MI 49588-8695

/s/ Maia H. Harris

Exhibit 1

US005841018A

United States Patent [19]

Watson et al.

[11] **Patent Number: 5,841,018**

[45] **Date of Patent: Nov. 24, 1998**

[54] **METHOD OF COMPENSATING FOR INSTALLATION ORIENTATION OF AN ATTITUDE DETERMINING DEVICE ONBOARD A CRAFT**

[75] Inventors: **Gary Stewart Watson**, Ada; **Krishna Devarasetty**, Kentwood, both of Mich.

[73] Assignee: **B. F. Goodrich Avionics Systems, Inc.**, Akron, Ohio

[21] Appl. No.: **785,553**

[22] Filed: **Dec. 13, 1996**

[51] **Int. Cl.**^{6} **G01C 17/38**; G01C 21/00

[52] **U.S. Cl.** .... **73/1.81**; 73/178 R; 244/164

[58] **Field of Search** .... 73/1.79, 1.81, 73/1.78, 1.75, 1.76, 1.77, 178 R; 244/164, 171

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,881,258	5/1975	Iddings	324/247
4,212,443	7/1980	Duncan et al.	244/177
4,318,300	3/1982	Maughmer .	
4,777,818	10/1988	McMurtry	73/1.79
4,982,504	1/1991	Söderberg et al.	73/1.79
5,313,410	5/1994	Watts	73/1.79
5,543,804	8/1996	Buchler et al.	342/357
5,562,266	10/1996	Achkar et al.	73/1.79
5,612,687	3/1997	Cescon et al. .	

FOREIGN PATENT DOCUMENTS

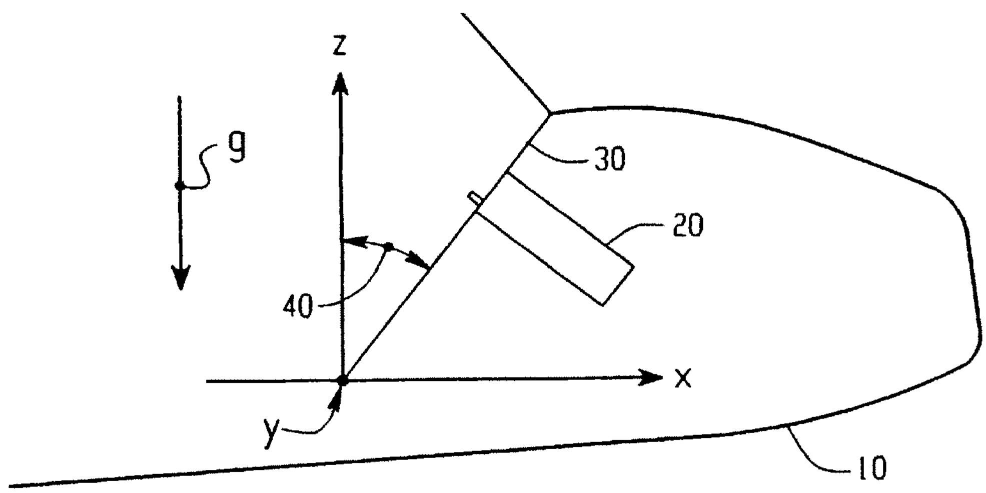
0 744 590 A2	11/1996	European Pat. Off. .
1 574 270	9/1980	United Kingdom .
WO 87/01349	3/1987	WIPO .

Primary Examiner—Max H. Noori
Attorney, Agent, or Firm—William E. Zitelli

[57] **ABSTRACT**

In accordance with the disclosed method, an attitude determining device which is installed onboard a mobile craft, like an aircraft, for example, at an unknown orientation with respect to the reference coordinate system of the craft senses its installation orientation with respect to an earth frame coordinate system when the craft is at rest to obtain a static orientation measurement thereof. Thereafter, an attitude of the mobile craft with respect to the earth frame is measured with the attitude determining device and such measurement is compensated with the static orientation measurement to obtain attitude information of the craft's reference coordinate system with respect to the earth frame coordinate system. The installation orientation of the attitude determining device may be sensed while the craft is at rest in either a leveled or unleveled condition.

20 Claims, 4 Drawing Sheets



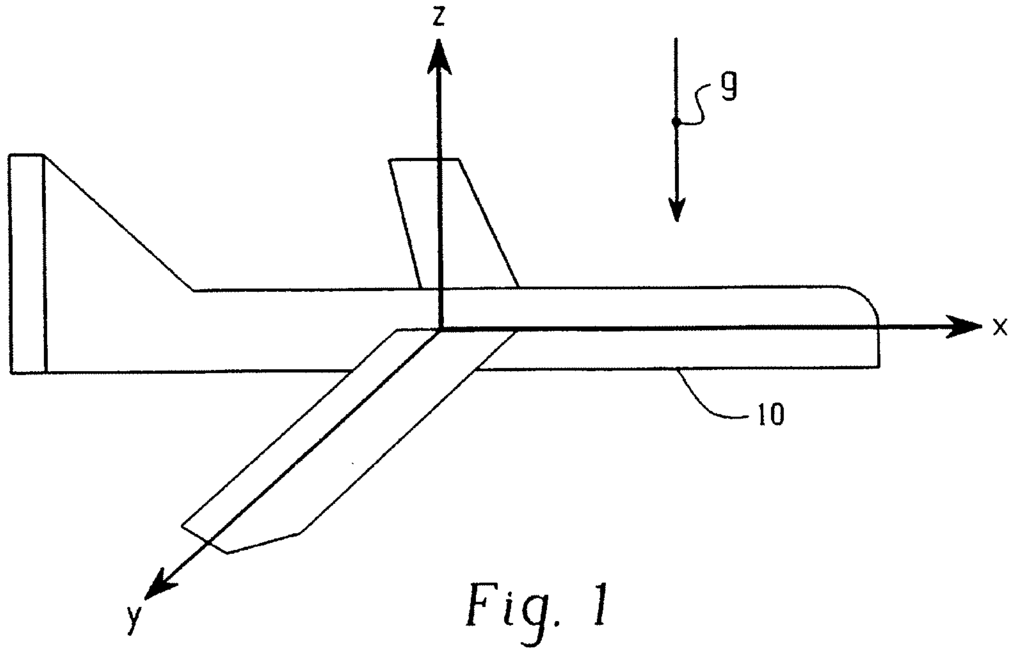


Fig. 1

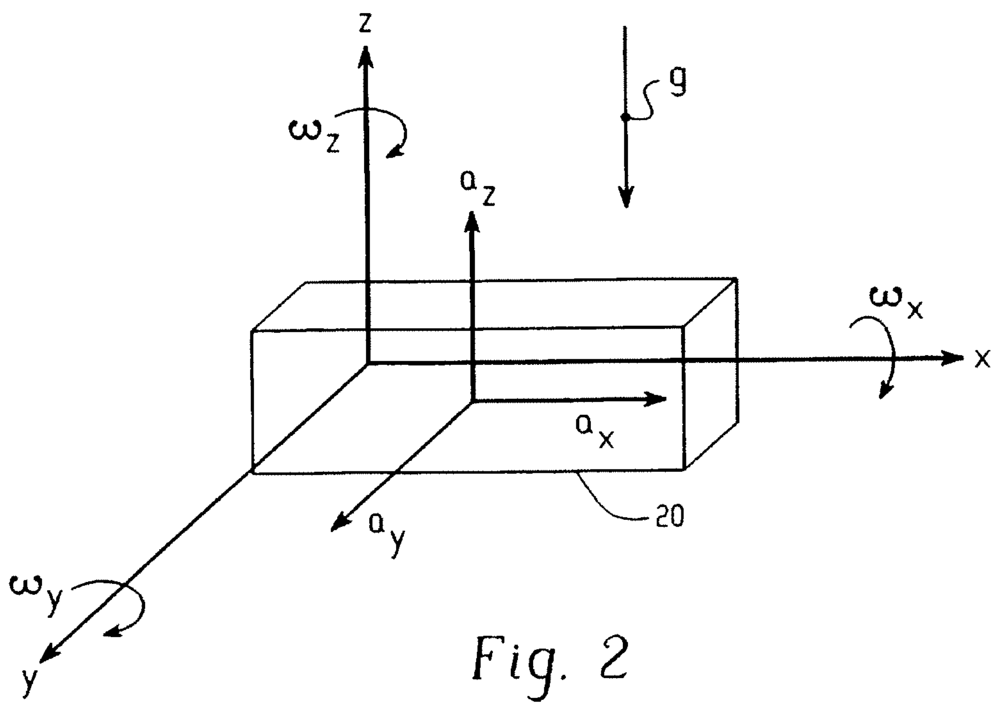


Fig. 2

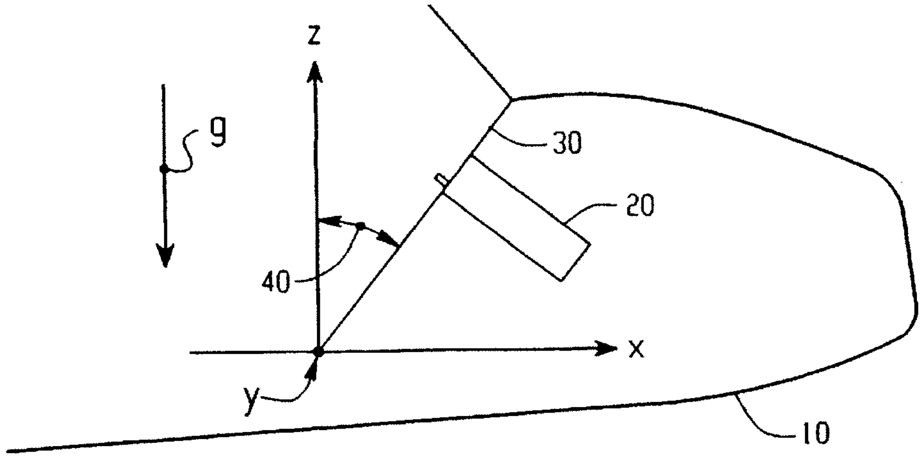


Fig. 3

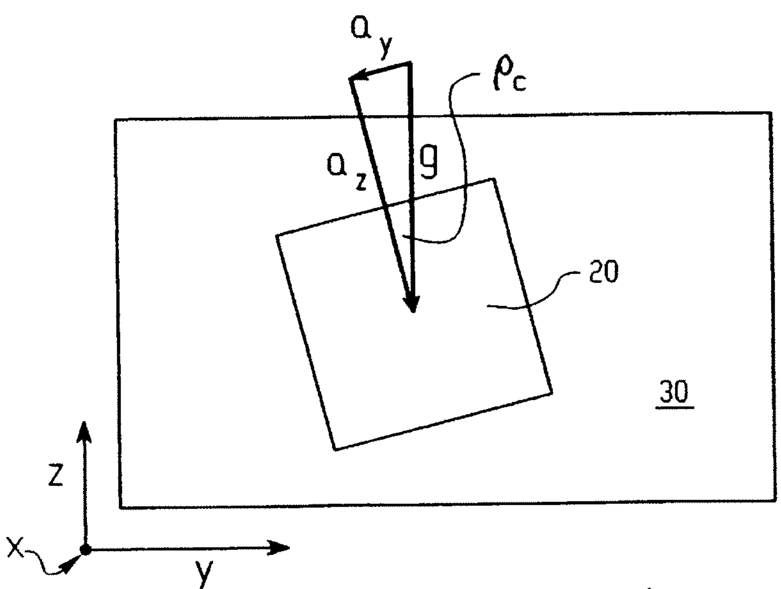


Fig. 4A

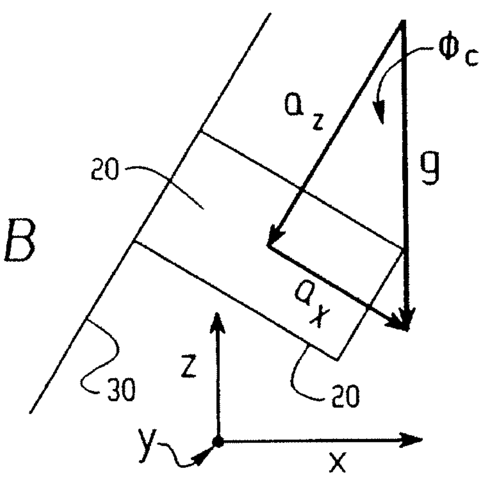
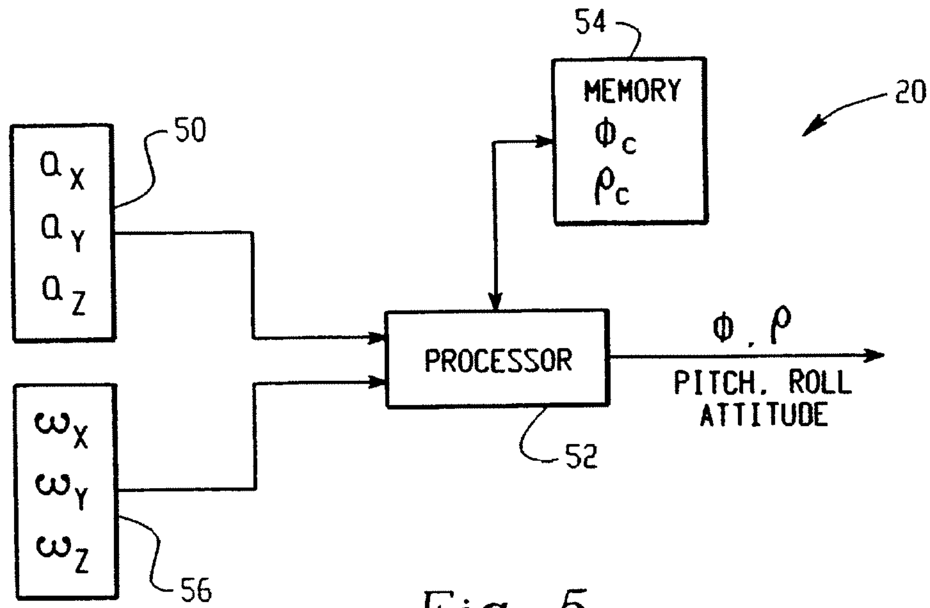
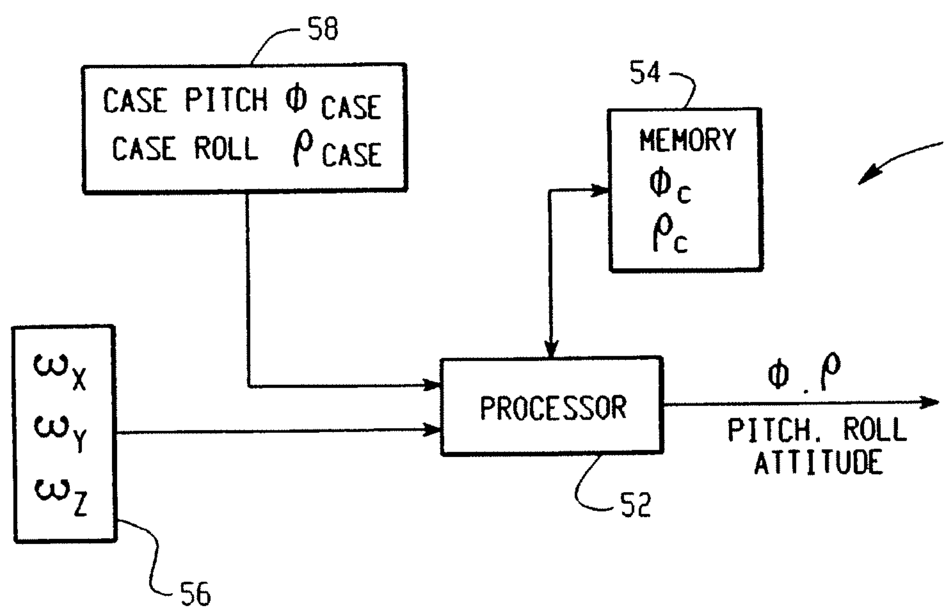


Fig. 4B



54
MEMORY
Φ_c
ρ_c
20
50
a_X
a_Y
a_Z
PROCESSOR
Φ, ρ
PITCH, ROLL ATTITUDE
52
ω_X
ω_Y
ω_Z
56

Fig. 5



58
CASE PITCH Φ CASE
CASE ROLL ρ CASE
54
MEMORY
Φ_c
ρ_c
20
ω_X
ω_Y
ω_Z
PROCESSOR
Φ, ρ
PITCH, ROLL ATTITUDE
52
56

Fig. 6

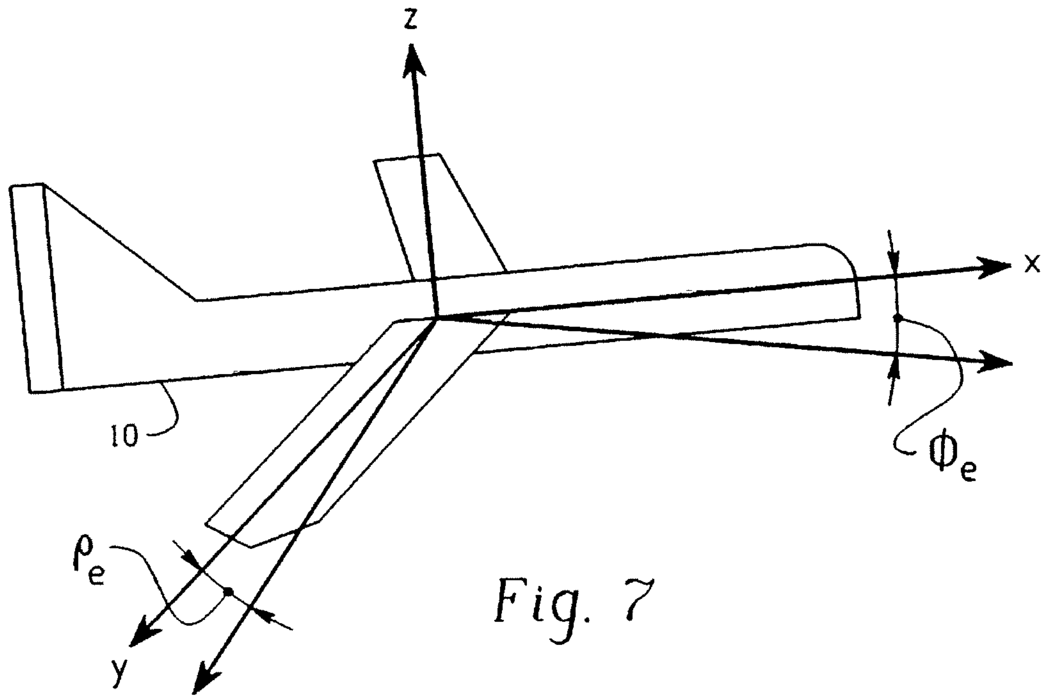


Fig. 7

METHOD OF COMPENSATING FOR INSTALLATION ORIENTATION OF AN ATTITUDE DETERMINING DEVICE ONBOARD A CRAFT

BACKGROUND OF THE INVENTION

The present invention relates to attitude determining devices onboard a mobile craft for determining the attitude of the craft's reference coordinate system with respect to an earth frame of reference, and more specifically, to a method of compensating an attitude measurement of such device for an unknown installation orientation with respect to the reference coordinate system of the craft.

Attitude determining devices for mobile craft, like aircraft, for example, measure the attitude of the moving craft with respect to an outside reference coordinate system, typically known as earth frame. The devices may be installed at a location in the craft in such a manner to be mechanically aligned with the reference coordinate system of the craft. The reference coordinate system of conventional aircraft comprises three orthogonal axes which include a longitudinal or X axis, a lateral or Y axis, and a vertical or Z axis. Motion of the aircraft is generally described as roll which is a rotation about the X axis, pitch which is a rotation about the Y axis and yaw which is a rotation about the Z axis. Pitch, roll and yaw positions are measured as the current angle between the aircraft reference coordinate system and earth frame. Conventionally, aircraft attitude determining devices primarily measure attitude of the aircraft in pitch and roll.

Any inaccuracy in installing an attitude determining device in the craft with respect to the reference coordinate system thereof will result in inaccurate measurement and presentation of the attitude of the craft to either the pilot or other system using the attitude information for display or control purposes. Currently, a method of installing these devices in an aircraft has been to accurately level the aircraft first, and then, install the device using shims or other mechanical apparatus to correctly position the device with respect to the three orthogonal axes forming the coordinate system of the aircraft. This procedure of leveling is adequate for devices mounted in locations of the aircraft remote from the cockpit, but when the device is to be mounted in a cockpit location, such as on an instrument panel, for example, shimming or other mechanical means of adjusting the installation orientation thereof may be precluded due to viewing angle restrictions, aesthetics, . . . etc. Accordingly, some other compensation method will be required.

Currently, units installed on an instrument panel in the cockpit of an aircraft have slots for roll axis alignment and internal mechanical means to accommodate pitch angles other than zero. However, these accommodations for pitch angles make the assumption of zero error in manufacturing tolerances of the aircraft panel angle.

Accordingly, the inventive method described herein below ensures a substantially accurate measurement of aircraft attitude by the attitude determining device with respect to the earth frame of reference. The static installation orientation is automatically determined by the device itself and the attitude measurement is compensated therewith in a processor of the device. Thus, the drawbacks of the current mechanical leveling and alignment procedures are avoided.

SUMMARY OF THE INVENTION

In accordance with the present invention, an attitude determining device which is installed onboard a mobile craft at an unknown orientation with respect to the reference coordinate system of the craft senses its installation orientation with respect to an earth frame coordinate system when the craft is at rest to obtain a static orientation measurement. An attitude of the mobile craft is measured with the attitude determining device and such measurement is compensated with the static orientation measurement to obtain attitude information of the craft's reference coordinate system with respect to the earth frame coordinate system.

In one embodiment, the acceleration of the attitude determining device is sensed for each of the axes of the reference coordinate system of the mobile craft while at rest and leveled, and a static attitude pitch and static attitude roll of the device are determined from trigonometric functions of ratios of the sensed accelerations. Accordingly, both of the measured attitude pitch and roll of the device are compensated with the static attitude pitch and the static attitude roll, respectively, in the attitude determining device to render attitude information of the craft's reference coordinate system with respect to the earth frame coordinate system.

In another embodiment, a static attitude of the mobile craft in pitch and roll is obtained while the craft is at rest and unleveled. Thereafter, the static attitude craft pitch is used in determining the static attitude pitch of the device and the static attitude craft roll is used in determining the static attitude roll of the device and such static attitude pitch and roll are used respectively to compensate for the measured attitude pitch and roll of the mobile craft in the attitude determining device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration of an aircraft, with it's reference coordinate system, onboard which an attitude determining device may be installed.

FIG. **2** is an illustration of an attitude determining device including conventional internal acceleration and rate sensors for three orthogonal axes X, Y and Z.

FIG. **3** is a sketch of an attitude determining device mounted on a panel in the cockpit of an aircraft at an unknown orientation to the reference coordinate system of the craft.

FIGS. **4A** and **4B** are illustrations exemplifying methods of determining the pitch and roll of the attitude determining device onboard a mobile craft using sensed acceleration measurements of the device in accordance with the present invention.

FIG. **5** is a block diagram schematic representing a suitable embodiment of an attitude determining device for performing the method in accordance with the present invention.

FIG. **6** is a block diagram schematic representing an alternate embodiment of an attitude determining device for performing another aspect of the present invention.

FIG. **7** is an illustration of an aircraft having its reference coordinate system unleveled with respect to an earth frame coordinate system allowing for offset angles of pitch and roll respectively from a level attitude.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For the present embodiment, an aircraft will be used, by way of example, as a mobile craft, but it is understood that other similar craft may be used where ever an attitude of the craft is desired and measured with respect to an earth frame of reference coordinate system, hereinafter referred to sim-

ply as earth frame. An aircraft with its reference coordinate system is shown in FIG. **1** including a longitudinal axis depicted as an X axis, a lateral axis depicted as a Y axis, and a vertical axis depicted as a Z axis. Accordingly, roll of the aircraft may be measured as the angular rotation about the X axis, pitch of the aircraft may be measured by the angular rotation about the Y axis and yaw of the aircraft may be measured by the angular rotation about the vertical Z axis. All of these angles are measured with respect to the earth frame. Conventionally, an attitude determining device of an aircraft measures attitude in pitch and roll.

To accurately level the aircraft **10** such that its reference coordinate axes coincides with earth frame, the aircraft is adjusted in attitude such that an acceleration a_z sensed for the Z axis is set substantially equal to a gravity vector g, and the accelerations sensed in the X axis, a_x and in the Y axis, a_y, are set substantially to zero. When these conditions are sensed and stabilized, the aircraft **10** is considered leveled.

FIG. **2** is an illustration of an attitude determining device **20** which may include conventional internal acceleration sensors for the three orthogonal axes X, Y and Z, and may also include conventional rate sensors to measure the rotational motion ω_x, ω_y, and ω_z which are the rotational motions about the respective axes X, Y and Z. An example of such a device is an inertial reference unit manufactured by Honeywell, Inc., model no. HG2001AB02. The internal acceleration sensors (not shown) determine the gravity vector or local vertical g. Thereafter, rotational motion about the respective axes X, Y and Z is sensed by the rate sensors (also not shown), the output of which being integrated over time to maintain a real time craft attitude. Any accumulated integration errors may be removed during static periods by re-aligning the derived output of the device to the local vertical g which procedure is referred to as leveling or erection. These calculations are conventionally performed by a processor internal to the device which samples the sensor outputs and performs the initial and continuous algorithms to produce an attitude solution to be used for display in the aircraft or for a guidance and/or control application for the aircraft.

The attitude determining device **20** may be of a strap down system which is mechanically mounted to the case of the device or a gimballed instrument having elements which are free to rotate in inertial space independent of the case of the unit. In either case, in locating the attitude determining device **20** on board a moving craft, like an aircraft, for example, it may be installed at an unknown orientation with respect to the reference coordinate system of the craft which in the present embodiment are the three orthogonal axes X, Y and Z. It is desired that the device be mounted level with the lateral and longitudinal axes of the craft and aligned with the longitudinal X axis such as shown in FIG. 2, but this may not always be possible due to errors in mechanical leveling or adjusting of the orientation and due to errors in manufacturing tolerances of the device and the aircraft structure where the device is being mounted. This is especially evident when the attitude determining device **20** is mounted on a panel in the cockpit of the aircraft **10** much as illustrated in the sketch of FIG. **3**.

Referring to FIG. **3**, when the attitude determining device **20** is installed on an aircraft instrument panel **30**, the device may not be aligned with the "waterline" or level line of the aircraft in order to compute accurate attitude information. This is because the panel is often not perpendicular to the waterline and it is not possible in most cases to exactly compensate mechanically for the panel angle offset **40** to the vertical or Z axis. In accordance with the present invention, a method is described below which ensures an accurate calculation of the attitude of a moving craft, like an aircraft, for example, by measuring the installation orientation of the device **20** with respect to the reference coordinate axes of the aircraft and compensating for this orientation mathematically in a processor of the device **20**.

In the present embodiment, upon installation of the device **20** on the instrumentation panel **30** of the craft **10**, whose reference coordinate axes have been leveled to coincide with earth frame, the installation orientation thereof is automatically measured by the installed device **20** and stored in a non-volatile memory thereof. For example, the pitch, ϕ_c and the roll, ρ_c are measured using the acceleration sensors of the device **20** and this measurement is exemplified by the illustrations of FIGS. **4A** and **4B**. In FIG. **4A**, the panel **30** and mounted device **20** is shown in the plane of the axes Z and Y to describe the measurement of the roll angle ρ_c of the installed device **20**. In the plane of the axes Z and Y, the acceleration vectors a_y and a_z are added vectorially to yield the gravity vector g. The installation roll angle ρ_c about the X axis is the angle between the vectors g and a_z and may be determined mathematically in accordance with a trigonometric function of the ratio of a_y to a_z.

Similarly, the perspective of the device **20** installed on the panel **30** in the plane of the axes X and Z is shown in FIG. **4B**. Referring to FIG. **4B**,in this perspective, the acceleration vectors a_z and a_x add up vectorially to yield the gravity vector g and the pitch angle ϕ_c is the angle between the vectors g and a_z which is a rotation about the Y axis. The installation pitch angle ϕ_c may be determined mathematically in accordance with a trigonometric function of the ratio of a_x to a_z. In the present embodiment, the trigonometric function used for determining the installed roll and pitch angles for static orientation of the device **20** is the arcsine.

A block diagram schematic representing a suitable embodiment of the attitude determining device is shown in FIG. **5**. Referring to FIG. **5**, after the device is installed on the instrument panel of a leveled craft **10**, for example, and power is subsequently activated to the device **20**, an internal processor **52** of the device **20** samples the outputs of the acceleration senors depicted in the block **50** in all three axes a_x,a_y,a_z. The static angles of the device **20** with respect to earth frame are determined by the processor **52** from the static acceleration measurements based on the trigonometric function described above. The installation angles ϕ_c and ρ_c are read from non-volatile memory **54** of the device **20** and the attitude of the craft **10** with respect to earth frame is determined by the processor **52** by subtracting these installation angles ϕ_c and ρ_c from the static angles of the device **20** with respect to earth frame. Thereafter, the pitch and roll attitude angles of the moving craft **10** are computed conventionally by the processor **52** via the rate sensors ω_x, ω_y ω_z which are shown at block **56** of the device **20** and received by the processor **52**. In a gimballed attitude determining device the angles of the spin axis, measured using synchros or other such devices, with respect to the case are corrected by subtracting the installation angles ϕ_c and ρ_c to yield actual aircraft pitch and roll attitude angles.

In summary, for the case in which the craft is leveled according to the description supplied above prior to sensing the installation orientation of device **20**, the processor **52** samples the outputs a_x,a_y and a_z of the acceleration sensors **50**. The static installation angles ϕ_c and ρ_c are determined by the processor **52** from the static acceleration measurements based on the trigonometric function described above and are stored in a non-volatile memory **54** for use in compensating the attitude measurements with respect to earth frame.

Power to device **20** may then be removed. Subsequent power application to device **20** would allow a measurement of the attitude of the aircraft, i.e. orientation of the aircraft's reference coordinate axes with respect to earth frame, to be correctly determined by processor **52** using ϕ_c and ρ_c from the memory **54**.

In some applications, the attitude determining device **20** may not include acceleration sensors **50** but rather include level sensors for sensing directly the pitch ϕ_{case} and roll ρ_{case} of the installed case with respect to the earth frame. A block diagram schematic suitable for exemplifying an alternate embodiment of the device **20** including level sensors is shown in FIG. **6** with the level sensing depicted at **58**. Like reference numerals are given to the other elements of the device **20** to match those described in connection with the embodiment of FIG. **5**. In operation, the processor receives the installation orientation angles ϕ_{case} and ρ_{case} measured by the level sensors at **58** and stores them in the non-volatile memory **54** as ϕ_c and ρ_c to be accessed subsequently in compensating for the attitude angle measurements as described in connection with the embodiment of FIG. **5**.

The foregoing method provides for compensating for the installation orientation of the device **20** for a leveled craft. If the craft **10** is not in a level attitude as shown in the exemplified illustration of FIG. **7**, the actual unlevel aircraft attitude may be measured i.e. reference coordinate axes of the aircraft with respect to earth frame, allowing the processor **52** to determine the offset angles of pitch and roll, ϕ_e and ρ_e, respectively, from a level attitude. These pitch and roll angle offsets from a level condition of the aircraft may be input either manually or electrically to the processor **52** of the device **20** as shown in FIGS. **5** and **6**. In addition, the static installation angles are measured by device **20** with respect to the unleveled aircraft coordinate axes. In order for the processor **52** of device **20** to calculate the effective static installation pitch and roll angles, ϕ_c and ρ_c of the case with respect to a level reference coordinate system of the craft **10**, it may subtract the measured offset angles from their respective measured installation angles. The effective static orientation measurements of the case with respect to the craft's reference coordinate system may then be stored in the memory **54** as shown in FIGS. **5** and **6** in order to compensate for the installation orientation of the device in the craft **10** as described supra.

In attitude determining devices in which there is no non-volatile memory, the step of sensing the installation orientation of the device to obtain a static orientation measurement with respect to the reference coordinate system of the craft may be performed each time the power is turned on and the aircraft is in a static condition. The resulting static orientation measurement may be stored in the memory of the device for use in compensating for attitude measurements for the moving craft.

While the invention has been described herein in connection with a preferred embodiment, it should not be so limited, but rather construed in accordance with the breath and broad scope of the claim set appended hereto.

We claim:

1. A method of compensating for installation orientation of an attitude determining device on-board a mobile craft with respect to a reference coordinate system of said craft to obtain attitude information of said craft from said device based on an earth frame coordinate system, said method comprising the steps of:

installing said attitude determining device on-board said mobile craft at an unknown orientation with respect to said reference coordinate system of said craft;

sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device;

measuring an attitude of said mobile craft with said attitude determining device; and

compensating said craft attitude measurement of said device with said static orientation measurement to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.

2. The method in accordance with claim **1** wherein the reference coordinate system of said craft includes three orthogonal axes—a vertical or z axis, a longitudinal or x axis and a lateral or y axis.

3. The method in accordance with claim **2** wherein the step of sensing includes:

leveling the craft while at rest such that the z axis is aligned with a gravity vector and no substantial at rest acceleration exists at the x and y axes;

sensing the acceleration at the device for each of said three axes—a(x), a(y) and a(z) while the craft is at rest and leveled; and

determining the static orientation measurement of said device based on a function of said three sensed axis accelerations—a(x), a(y) and a(z).

4. The method in accordance with claim **3** wherein the step of determining includes:

determining a static attitude pitch of the device as a trigonometric function of a ratio of the sensed accelerations a(x) and a(z); and

determining a static attitude roll of the device as a trigonometric function of a ratio of the sensed accelerations a(y) and a(z); and

wherein the static orientation measurement of the device comprises the determined static attitude pitch and static attitude roll.

5. The method in accordance with claim **4** wherein the step of measuring includes measuring an attitude pitch and an attitude roll of the mobile craft with said device; and the step of compensating includes compensating the measured attitude pitch with the static attitude pitch and compensating the measured attitude roll with the static attitude roll.

6. The method in accordance with claim **2** wherein the step of sensing includes:

sensing the acceleration at the device for each of said three axes—a(x), a(y) and a(z) while the craft is at rest and unleveled;

obtaining a static attitude of the craft while at rest and unleveled;

determining the static orientation measurement of said device based on said static craft attitude and a function of said three sensed axis accelerations—a(x), a(y) and a(z).

7. The method in accordance with claim **6** wherein the step of obtaining includes:

obtaining a static craft pitch and a static craft roll; and

the step of determining includes:

determining a static attitude pitch of the device as a trigonometric function of a ratio of the sensed accelerations a(x) and a(z) and said static craft pitch; and

determining a static attitude roll of the device as a trigonometric function of a ratio of the sensed accelerations a(y) and a(z) and said static craft roll; and

wherein the static orientation measurement of the device comprises the determined static attitude pitch and static attitude roll.

8. The method in accordance with claim 7 wherein the step of measuring includes measuring an attitude pitch and an attitude roll of the mobile craft with said device; and the step of compensating includes compensating the measured attitude pitch with the static attitude pitch and compensating the measured attitude roll with the static attitude roll.

9. The method in accordance with claim 1 wherein the step of sensing includes:

leveling the craft while at rest;

sensing an installation pitch and an installation roll of the device while the craft is at rest and leveled; and

wherein the static orientation measurement of the device comprises the sensed installation pitch and roll of the device.

10. The method in accordance with claim 9 wherein the step of measuring includes measuring an attitude pitch and an attitude roll of the mobile craft with said device; and the step of compensating includes compensating the measured attitude pitch with the sensed installation pitch and compensating the measured attitude roll with the sensed installation roll.

11. The method in accordance with claim 1 wherein the step of sensing includes:

sensing an installation pitch and an installation roll of the device while the craft is at rest and unleveled;

obtaining a static attitude pitch and a static attitude roll of the craft while at rest and unleveled;

determining a static attitude pitch of said device based on a combination of said static craft attitude pitch and said installation pitch and a static attitude roll of the device based on a combination of said static craft attitude roll and said installation roll;

wherein the static orientation measurement of the device comprises the determined static device attitude pitch and static device attitude roll.

12. The method in accordance with claim 11 wherein the step of measuring includes measuring an attitude pitch and an attitude roll of the mobile craft with said device; and the step of compensating includes compensating the measured attitude pitch with the static device attitude pitch and compensating the measured attitude roll with the static device attitude roll.

13. The method in accordance with claim 1 wherein the mobile craft is an aircraft, and the attitude device is installed on an instrumentation panel of said aircraft.

14. The method in accordance with claim 1 wherein the attitude determining device comprises a strapdown attitude instrument.

15. The method in accordance with claim 1 wherein the attitude determining device comprises a gimballed attitude instrument.

16. A method of compensating for installation orientation of an attitude determining device on-board a mobile craft with respect to a reference coordinate system of said craft to obtain attitude information of said craft from said device based on an earth frame coordinate system, said method comprising the steps of:

installing said attitude determining device on-board said mobile craft at an unknown orientation with respect to said reference coordinate system of said craft;

sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device;

storing said static orientation measurement in a memory;

measuring an attitude of said mobile craft with said attitude determining device;

retrieving said static orientation measurement from said memory to a processor of said device; and

compensating said craft attitude measurement with said retrieved static orientation measurement in said processor to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.

17. The method in accordance with claim 16 wherein the step of sensing includes:

sensing the installation orientation of the device with sensors disposed at the device;

receiving in the processor sensed orientation data of said sensors; and

processing the received data in the processor to obtain the static orientation measurement of the device.

18. The method in accordance with claim 17 wherein the step of sensing includes sensing the installation orientation of the device with acceleration sensors.

19. The method in accordance with claim 17 wherein the step of sensing includes sensing the installation orientation of the device with level sensors.

20. The method in accordance with claim 16 wherein the step of compensating includes:

obtaining a static attitude of the craft while at rest and unleveled;

providing said static craft attitude to the processor of said device; and

compensating said craft attitude measurement with said retrieved static orientation measurement and static craft attitude in said processor to obtain attitude information of the craft's reference coordinate system with respect to the earth frame coordinate system.

* * * * *

Exhibit 2

UNITED STATES DISTRICT COURT
DISTRICT OF MASSACHUSETTS

AVIDYNE CORPORATION, a Delaware corporation, Plaintiff, v. L-3 COMMUNICATIONS AVIONICS SYSTEMS, INC., f/k/a B.F. GOODRICH AVIONICS SYSTEMS, INC., a Delaware corporation, Defendant.	Civil Action No. 05-11098 GAO

STIPULATION AS TO AGREED-UPON CLAIM CONSTRUCTION OF CERTAIN TERMS CONTAINED WITHIN CLAIMS 1 AND 16 OF UNITED STATES PATENT 5,841,018

IT IS HEREBY STIPULATED by and between Plaintiff Avidyne Corporation, and Defendant L-3 Communications Avionics Systems, Inc., through their counsel of record, that for purposes of the above identified action only:

1. The term ATTITUDE as used in United States Patent 5,841,018 ('018 Patent) means "the angular position of a craft relative to a frame of reference, such as but not limited to the amount of tilting about the wings and body of an aircraft relative to the earth."

2. The term REFERENCE COORDINATE SYSTEM as used in the '018 Patent means "A system of coordinates, or values, using a reference point, or starting point, for navigation."

3. The term EARTH FRAME COORDINATE SYSTEM as used in the '018 Patent means "a theoretical frame of reference defined by the earth's surface and a vertical axis that is in the direction of gravity (perpendicular to the earth's surface)."

4. The term INSTALLING SAID ATTITUDE DETERMINING DEVICE ON-BOARD SAID MOBILE CRAFT as used in the '018 Patent means "securing, mounting, or affixing the attitude determining device to the mobile craft."

5. The term UNKNOWN ORIENTATION WITH RESPECT TO SAID REFERENCE COORDINATE SYSTEM OF SAID CRAFT as used in the '018 Patent means "unknown angular position of the installed attitude determining device relative to the reference frame of the craft."

6. The term MOBILE CRAFT as used in the '018 Patent means "a space, air, land, or water vessel or vehicle, manned or unmanned, capable of moving."

Agreed to this 28 day of September 2006 by:

AVIDYNE CORPORATION By its attorneys, /s/ Maia H. Harris Jason Kravtiz Maia Harris NIXON PEABODY LLP 100 Summer Street Boston, MA (617) 345-1000 Frank W. Ryan NIXON PEABODY LLP 437 Madison Ave New York, NY 10022 (212) 940 3000	**L-3 COMMUNICATIONS AVIONICS SYSTEMS, INC.,** By its attorneys, /s/Karl Ondersma (with consent by Maia Harris) Brendan M. Hare HARE & CHAFFIN 160 Federal Street Boston, MA 02110 (617) 330-5000 Terence J. Linn VAN DYKE, GARDNER, LINN & BURKHART, LLP 2851 Charlevoix Drive, S.E. P.O. Box 888695 Grand Rapids, MI 49588 (616) 975-5500

IT IS SO ORDERED.

DATED: ________________

GEORGE A. O'TOOLE, JR.

United States District Judge

Exhibit 3

EXPERT REPORT OF MARSHALL H. KAPLAN, PH.D.

I. QUALIFICATIONS:

I am skilled in the art of attitude determining devices as a result of my educational and professional experiences. I received a B.S. in Aeronautical Engineering (with honors) from Wayne State University, followed immediately by a Master's degree in Aeronautics and Astronautics from M.I.T. After four years of industrial experience, I attained a Ph.D. degree in Aeronautical and Astronautical Sciences from Stanford University. My Ph.D. dissertation dealt with the problem of motion and control of a mobile craft on the lunar surface.

Over the past four decades, I have served as Professor of Aerospace Engineering at the Pennsylvania State University (PSU) for 13 years where I taught several engineering courses including aircraft flight test engineering and autopilot design. After leaving PSU I served as a consultant to many companies and government agencies on the technical aspects of navigation, guidance and control (GN&C) of aerospace vehicles, including aircraft, missiles and launch vehicles. Since 1970, I have taught professional development courses on GN&C to engineers working in the aeronautics and astronautics industry, NASA and the US Air Force.

During my tenure at PSU I wrote "Modern Spacecraft Dynamics and Control," a senior and graduate level engineering textbook. Part of this book addresses the technologies of gyros, inertial navigation, orientation sensing and attitude control.

I have been an aircraft pilot since 1968, and am licensed to fly multiengine aircraft. I also hold an instrument rating and have logged more than 3,700 hours of flight time. I have been a part owner of six different aircraft and I currently fly a high-performance single-engine airplane. I am intimately familiar with aircraft systems, instruments, sensors and autopilots.

I am affiliated with several professional organizations, e.g., a Fellow of the American Institute of Aeronautics and Astronautics and a Fellow of the American Astronautical Society.

I am being paid $200 per hour (non testifying) or $400 per hour (testifying) as compensation for my services to Avidyne in this action.

II. PUBLICATIONS IN LAST 10 YEARS

"X-33 and VentureStar. Is this a Paradox?" M. H. Kaplan, Launchspace Magazine, Vol. 1, No. 3, Fall 1996.

“The Reusable Launch Vehicle: Is the Stage Set?” M. H. Kaplan, Launchspace Magazine, Vol. 2, No. 1, March 15, 1997.

“Unobtainium: The Ultimate Space Material,” M. H. Kaplan, Launchspace Magazine, Vol. 3, No. 2, June 1998.

“Basic Recipe for RLVs,” M. H. Kaplan, Launchspace Magazine, Vol. 4, No. 2, March/April 1999.

“Which is Better? A Reusable First Stage or Second Stage?” M. H. Kaplan, Launchspace Magazine, Vol. 4, No. 3, May/June 1999.

“Kaplan’s Laws – Distribution of Complexity Between the Stages of a Two-Stage Launcher System,” M. H. Kaplan, Launchspace Magazine, Vol. 4, No. 4, July/August/September 1999.

“Kaplan’s Laws – Are RLVs Economically Viable?” M. H. Kaplan, Launchspace Magazine, Vol. 4, No. 5, October/November 1999.

“Kaplan’s Laws – What’s the Best Configuration for Next-Generation RLVs?” M. H. Kaplan, Launchspace Magazine, Vol. 5, No. 1, February 2000.

“Kaplan’s Laws - The Launcher Market: How Much Will It Give?” M. H. Kaplan, Launchspace Magazine, Vol. 5, No. 2, March 2000.

“Will the Ongoing Drama of Reducing Launch Costs Ever Have a Happy Ending?” M. H. Kaplan, Launchspace Magazine, Vol. 5, No. 7, September 2000.

“The State of the Launch Vehicle Industry,” M. H. Kaplan, Pacific Telecommunications Review, Vol. 24, No. 1, 3rd Quarter 2002.

“The Next Generation of Launch Vehicles for America,” M. H. Kaplan, presented at the 1996 AIAA Space Programs And Technologies Conference, Huntsville, AL, AIAA Paper No. 96-4425, September 24-26, 1996.

“The International Market,” M. H. Kaplan, presented at the 1st FAA Commercial Space Transportation Forecast Conference, Washington, DC, February 10-11, 1998.

“The ‘Laws’ of Reusable Launch Vehicle Design,” M. H. Kaplan, presented at the 2nd Annual FAA Commercial Space Transportation Forecast Conference, Washington, DC, February 10-11, 1999.

“Reusable Launch Vehicle Design Limitations,” M. H. Kaplan, presented to the AIAA Technical Committees on Space Transportation and Space Systems, Rosslyn, VA, March 10, 1999.

III. EXPERT OPINION

Regarding U.S. Patent 5,841,018 ("'018 Patent"), I have been asked to offer testimony regarding the general technology and the meaning of the patent claims.

A. Introduction to Mobile Vehicle Attitude Measurement and Initialization

Certain mobile vehicles, such as aircraft, make use of devices that automatically detect and record the orientation of the craft while flying in order to navigate and maintain a desired orientation. Some of these devices must rely on a reference orientation (or coordinate system) to which the instantaneous orientation of the craft is compared. For example, "straight and level flight" means the craft is flying in a straight line and its two navigational reference axes (pitch and roll) are parallel to the horizon. The "horizon" is an imaginary geometric plane that is perpendicular to the direction of local gravity at the position of the craft.

An attitude determining device of the type disclosed in the '018 Patent senses and measures its own attitude, which is typically taken as the attitude of the craft because of its precision alignment with the craft's reference coordinate system.

When an attitude determining device of the type disclosed in '018 Patent is placed in a mobile craft such that its orientation relative to the craft's reference axes is not specified, this device must determine its initial orientation while the craft is at rest in order to establish orientation compensation that is used while the craft is mobile. When such a device contains certain sensing instruments such as accelerometers that sense force and acceleration and gyroscopes that sense angular motion and a processor, this device can automatically determine its orientation relative to an earth frame coordinate system. Aircraft inertial guidance systems use such devices to determine aircraft orientation and position before and during flight.

The technique of inertial guidance originated early in the twentieth century with the appearance of the gyrocompass, but this technology did not become fully appreciated for navigational applications until after World War II. By 1960, C. Stark Draper published a text on inertial guidance.[1] Former Air Force Chief Scientist and Stanford professor, Robert Cannon, published an early paper in 1961 on accuracy issues related to the alignment of inertia guidance

---

[1] Draper, et al., *Inertia Guidance*, Pergamon Press, 1960.

systems.[2] An easily understandable explanation of inertial navigation systems was published in 1971 by Ken Britting in textbook format.[3]

Chapter 9 of Britting's book addresses self-alignment techniques and answers the question: "How does one use the outputs of the inertia instruments, which are resolved in the platform frame to determine the relationship between the platform frame and some reference frame?"[4] He states, "The problem of alignment of inertial navigation systems is basically that of determining the transformation matrix which relates vectors in the platform coordinate frame to the same vectors expressed in geographic coordinates or equivalent, in some other computation frame." In some cases the transformation matrix can be as simple as adding or subtracting two angles to compensate for the orientation of an attitude determining device.

In 1975, Hung and White[5] published a comprehensive description of self-alignment techniques for inertial measurement units (IMU), which are inertia navigation devices that evolved from land, sea and air vessels for use on guided missiles, launch vehicles and satellites. In self-alignment, an IMU is aligned to an earth-fixed coordinate system on the earth's surface by using the information derived from the output of the unit's sensors. This type of alignment is called "leveling and gyrocompassing."

B. Contribution to Claim construction:

In light of my experience and expertise in this field, the disputed claims and terms have the following definitions:

Attitude Determining Device

A device that includes sensors and a processor for processing the output of the sensors to determine attitude.

---

2 Cannon, Jr., R. H., "Alignment of Inertia Guidance Systems by Gyrocompassing – Linear Theory," J. Aerospace Sciences, November 1961.

3 Britting, K. R., Inertial Navigation Systems Analysis, Wiley-Interscience, 1971.

4 Britting, K. R., Inertial Navigation Systems Analysis, Wiley-Interscience, Ch. 9, 1971.

5 Hung, J. C. and White, H. V., "Self-Alignment Techniques for Inertial Measurement Units," IEEE Transactions on Aerospace and Electronic Systems, Vol. AES-11, No. 6, November 1975, pp. 1232-1247.

Sensing the installation orientation of said attitude determining device with respect to said earth frame coordinate system when said craft is at rest to obtain a static orientation measurement of said device.

Automatically determining the angular position of the installed attitude determining device relative to earth frame while the craft is not moving to obtain a static orientation measurement of the device.

Measuring an attitude of said mobile craft with said attitude determining device

Processing the output of the sensors of the attitude determining device to determine a pre-compensated attitude of the mobile craft.

Compensating said craft attitude measurement of said device with said static orientation measurement to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.

Applying said static orientation measurement (determined in said sensing step) to the pre-compensated attitude of the craft (determined in said measuring step) to mathematically correct the pre-compensated attitude of the craft (determined in said measuring step) by adjusting for the difference between that pre-compensated measured attitude of the craft and the craft's actual attitude relative to the earth frame.

Storing said static orientation measurement in memory

Persistently retaining the static orientation measurement in a memory.

Retrieving said static orientation measurement from said memory to a processor of said device.

Obtaining the previously stored static orientation measurement and feeding it to the processor of the attitude determining device.

Compensating said craft attitude measurement with said retrieved static orientation measurement in said processor to obtain attitude information of said craft's reference coordinate system with respect to said earth frame coordinate system.

Applying said retrieved static orientation measurement (determined in said sensing step) to the pre-compensated attitude of the craft (determined in said measuring step) in said processor to mathematically correct the pre-compensated attitude of the craft (determined in said measuring step) by adjusting for the difference between that pre-compensated measured attitude of the craft and the craft's actual attitude relative to earth.

Based on my experience and expertise these are correct constructions of these terms. Furthermore, the'018 Patent requires that each element of claims 1 and 16 must be followed in sequential order in order to practice the disclosed method. The correct construction of compensating step of claims 1 and 16 must reflect a sequential relationship of the preceding elements.

SIGNED:

Dated: October 2, 2006

Marshall H. Kapla

Marshall H. Kaplan, Ph.D.

EDUCATION

Ph.D.	Aeronautical and Astronautical Sciences, Stanford University, 1968
M.S.	Aeronautics and Astronautics, Massachusetts Institute of Technology, 1962
B.S.	Aeronautical Engineering, Wayne State University, 1961 (cum laude, ranked 1st in engineering)

UNIVERSITY FACULTY EXPERIENCE

Sep 1968 to Nov. 1981 - Professor
Department of Aerospace Engineering
Pennsylvania State University
University Park, PA

Courses taught include:

Performance of Aerospace Vehicles
Aircraft Design
Aircraft Propulsion
Principles of Flight Test Engineering
Aerodynamics
Aircraft Stability and Control
Aircraft Autopilot Design

HIGHLIGHTS OF FULL-TIME INDUSTRIAL EXPERIENCE

Institute for Defense Analyses - Research Staff
Strategic Insight, Ltd. - General Associate
Computational Technologies, Inc. - CEO
Launchspace, Incorporated - CEO
Veridian Incorporated - Program Director
EER Space Company - Chief Engineer
Kistler Aerospace - Chief engineer

PARTIAL LIST OF DOMESTIC CONSULTING CLIENTS

NASA Headquarters
Stanford University
Princeton University
George Mason University
Pennsylvania State University
JHU's Applied Physics Laboratory

RCA Astro Electronics Division
US General Accounting Office (GAO)
TRW Defense and Space Systems Group
Lockheed Martin
General Electric Co.
Loral Space and Communications
Boeing Company
Battelle
IBM

PROFESSIONAL MEMBERSHIPS

American Institute of Aeronautics and Astronautics (Fellow)
American Astronautical Society (Fellow)

HONOR SOCIETY MEMBERSHIPS

Tau Beta Pi (Engineering)
Omicron Delta Kappa (Leadership)
Sigma Pi Sigma (Physics)
Sigma Xi (Research)

HONORS RECEIVED

1995 Appointed to the National Research Council Study Group on Single-Stage-to-Orbit Launch Vehicle Technologies.
1978 Award for Outstanding Achievement in Research in the College of Engineering, Pennsylvania State University.
B.S. in Aeronautical Engineering with Distinction, 1961.
DuPont Memorial Fellowship, M.I.T., 1961-1962.
NASA Traineeship, Stanford University, 1966-1967.
NSF Traineeship, Stanford University, 1967-1968.

PATENT

"Attitude Acquisition Maneuver for a Bias Momentum Spacecraft," M. H. Kaplan, T. C. Patterson, and A. Ramos, Patent No. 4,306,692. December 22, 1981.